

- Fig. 13. *Leperditia marginata?* (young?), outline of the anterior aspect of the two valves united.
- Fig. 14. *Leperditia marginata?* (adult): *a*, cast of left valve; *b*, the same, dorsal aspect; *c*, the same, ventral aspect; *d*, anterior aspect.—British Museum.
- Fig. 15. *Leperditia marginata?*, cast of right valve.—Museum of Practical Geology.
- Fig. 16. *Leperditia Solvensis*, artificial cast of impression of right valve.—Museum of Practical Geology.

IX.—*Further Observations on the Development of Gonidia (?) from the Cell-contents of the Characeæ, and on the Circulation of the Mucus-substance of the Cell.* By H. J. CARTER, Esq., Assistant Surgeon H.C.S., Bombay.

[With two Plates.]

SINCE my first "Observations on the Development of Gonidia (?) from the Cell-contents of the Characeæ," &c.* were arranged, and which I then stated were not so "extended and complete" as they would have been had more leisure been at my disposal, I have obtained much more precise information on the subject. The inquiry was then new to me, and the only author to my knowledge who had engaged in it was Professor Pringsheim, who met with a similar formation in *Spirogyra*, &c.†, and had assumed, as the simplest way of accounting for it, that the ciliated bodies produced in this way were "propagative cells of the *Spirogyra* capable of development." In the "Postscript" to my "Observations," however, I expressed a different opinion, having at first, with Professor Pringsheim, been under the impression that a development of such "cells" under such circumstances could only belong to the plant in which it took place, and therefore I called them "gonidia." But subsequent observations favoured the view that they did not belong to *Nitella*, and therefore that they should have been called "monads;" viewing "monads" in the same relation to Infusorial that "gonidia" bear to future Algoid developments. That there is a great resemblance between gonidia and monads, and that there may be instances where their subsequent forms alone can determine which appellation should be used for them, in the sense mentioned, may be easily conceived, and the present is one to the beginner; but whether or not it should be so to the experienced observer, I will not now stop to discuss.

Like all unfinished investigations, my first communication

* Ann. and Mag. Nat. Hist. vol. xvi. No. 91. p. 1, 1855.

† *Id.* vol. xi. No. 64. p. 294, 1853.

will remain uninteresting until its subject is made more comprehensive, and it is on this account that I offer the following additional observations, which, together with figures of all that requires illustration in this, as well as in my former paper, will furnish a key to what I have already described, and enable the reader to correct for himself any false inferences which my remarks may have caused from my imperfect knowledge of a development, which at first appears more likely to be vegetable than animal, and though subsequently proved to be the contrary, is after all situated in that part of the scale of living beings with which we are least acquainted, and where many of the organisms so much resemble the lower orders of both vegetable and animal kingdoms, that on one day they are on this side the line of separation and another day on that, as discovery turns their balance in favour of one or the other of these great divisions of organic life.

With such introductory remarks let us proceed then to the different parts of the subject which require further elucidation.

It will be seen (at p. 6, *Obs. cit.**), that the "gonidia," which we shall henceforth call "monads," lost their cilium respectively and passed into polymorphic, reptant cells, each of which contained a contracting vesicle; in fact, into Rhizopoda; and here we must leave them for the present, considering them as *Amœbæ*, which might or might not have had an ulterior development.

Now we find by what Pringsheim has stated, that he not only observed a similar development in the cells of *Spirogyra*, but also in *Ædogonium*, *Cladophora fracta*, and in the young plants of *Nitella syncarpa*; to which I may here add the extent of my own experience in this matter, viz. that such developments are common in *Chara* and *Nitella*, *Cladophora* and *Spirogyra*; occasionally in *Hydrodictyon*; in *Closterium acerosum* and *Cosmarium* among the Desmidiæ, but never in the Diatomaceæ †; common in *Euglena* and in the dead bodies of Furcularian Rotifera. The same or similar developments probably take place throughout the whole of the freshwater Algæ and in many of the Infusoria, but I have only noticed them up to the present time in the organisms mentioned. Again, wherever I have seen them, they have appeared to me to have arisen from germs implanted in the Algæ or Infusoria in which they have occurred; and the organisms which have come from them have been *Amœbæ*, *Astasia*, or colourless flexible *Oscillatoria* (?). I am not certain that

* After this, the page alone of these "Observations" will be mentioned.

† The *Asteridia* of the Rev. W. Smith however appear to belong here, and that naturalist has seen them "occasionally in the Diatomaceæ." (*Quart. Journ. Microscop. Sc.* vol. i. p. 69.)

Pleotia should not be added to these, but until further observation proves this, I must leave it under doubt. May not the "spirozoids" also or "spermatospheres" of Itzigsohn belong to these developments? Their being developed in *Spirogyræ*, from globules of endochrome which become pale, lose their colour, and end in becoming "greyish-white," at least, gives them a strong resemblance. How the germs which produce these developments exist in the cells of *Algæ* without apparently affecting their vitality, or causing a suspension of their functions, is difficult to conceive; but that they do so, is proved by the presence at least of one kind generally, if not always, in the plants of Characeæ after they have attained a certain size, and to that we must now chiefly direct our attention.

My first observations on this development were made on the internodes of a very small species of *Nitella*, but latterly they have been made on the internodes of a very large one; some of the oldest of which average six inches in length by one twenty-fourth of an inch in breadth. Hence they were well adapted generally for experiments on this *Alga* *.

Let us now direct our attention to what takes place when one of these, about three or four inches in length, is so suspended, that about an inch of the free end may rest upon a slide of glass, in a little water, while a portion of the latter also is cut off with a lancet, and the rest covered with another piece of glass for observation.

1st. The *axial fluid* rushes forth and renders the *cell-wall* more or less flaccid.

2nd. The *mucus-layer* in part comes forth, and with it also portions of the *green layer*.

3rd. After a short time the expelled mucus, which is apparently separated into masses, but is nevertheless more or less

* There are two species of *Nitella* in the island of Bombay, the smallest of which I have already described, and the following is a description of the large one, or one in question :—

Plant long and straggling, of a deep green colour, with short branches, crowded towards the top. Oldest internodes 5-6 inches long, some fluted (from collapse?) where the endochrome has disappeared and left them of brown colour; terminal internodes shortened and crowded, comparatively. Verticils consisting of five short branches, each composed of 2-3 long cells applied end to end, the last terminated by a spine, five minute spines round each joint, and 10-12 or more round the base of each verticil; long branches rising between the short branches of the verticil. Organs of fructification cast together in the axil of the verticil or singly at the joints of the short branches. *Globule* spherical, of a brownish-green colour; *nucule* conical, at first white, then black. *General characters* :—Great length, dark-green colour, large organs of fructification and large size of plant generally. Grows in the tank of Nagaum in the island of Bombay.

connected by minute threads of its own material, is drawn back into the internode almost as quickly as it was ejected.

4th. By now moistening that part of the internode which is suspended, the mucus is again made to rush forth, and this backward-and-forward movement may be kept up for some time by alternately moistening and allowing the internode to get dry; or, by keeping the internode constantly moist, the whole of the mucus-contents may at once be discharged.

Here there is evidently a rapid endosmosis, and it would appear that the mucus-contents, which are within the *green layer*, are not expelled so much by the contraction of the latter, as I had inferred (p. 18), but depend for their exit upon the passage of water through *both* the *cell-wall* and the *green layer*; while the "spasmodic" retraction of the mucus mentioned in the same paragraph must be chiefly attributed to the drying up of the *cell-wall*, and consequent imbibition through the truncated end of the internode.

Green layer.—The structure of this has already been described, and the "green disk" was stated to consist of a transparent capsule or cell, within which is a green, flat disk or nucleus, of nearly equal diameter, presenting three or more granules in its composition. It is to the latter now that I chiefly wish to call attention. In these granules I had only been able to obtain a faint trace of starch by iodine, and therefore I left the question of their composition open, although I might have inferred from analogy that they were starch-grains. Subsequent observation has now proved to me that they are the rudiments of starch-grains, and that in some instances where the starch has been fully formed, they have increased to such an extent as to occupy the whole of the transparent capsule (Pl. VIII. fig. 5). Thus packed together of different sizes, they assume the rounded, subangular shapes of all similar bodies developed in a circumscribed space; at the same time they appear to have been formed at the expense of the green disk, whose substance is much wasted or has entirely disappeared.

Hence they are generated in the protoplasm of the cell; for if the green disk be exposed to the action of æther when the granules are very small, the colour of the nucleus disappears, but its form remains; while at a still earlier period it also appears to contain a nucleolus or cytoblast. Under what circumstances the granules come into existence I am ignorant; but that they have nothing to do with the cytoblast may be inferred from their appearance in the Diatomaceæ (*Navicula fulva*, &c.) outside the cell of the cytoblast or nucleus, and in the cavity or body of the frustule, which, up to the time of their appearance together with that of the oil-globules, is perfectly transparent.

Mucus-layer.—It has been already stated that when this rushes out it is found to be composed of a granuliferous mucus, globular vesicles, circular disks, and irregularly shaped opaque, yellowish bodies. The disks, which are circular in the small *Nitella*, are elliptical and elongate in the large one; and the irregularly shaped bodies, which have no particular figure in the small *Nitella*, are, for the most part, agariciform and patulous in the larger species. The same differences obtain also in *Chara verticillata* (Pl. VIII. figs. 7–16).

Although many of the globular vesicles present no nucleus, and many appear to be altogether void of granular contents, yet most present either a single nucleus or a plurality of such nuclei; and some which are very large contain a number of smaller nucleated vesicles like themselves; but the typical form of the globular vesicle consists of a transparent cell-wall filled with a granuliferous mucus, the grosser parts of which are more or less collected round the nucleus, which is fixed to or imbedded in its cell-wall (fig. 14); the nucleus being, in fact, equivalent to the "circular disk" (fig. 8); and where we see a plurality of them in a globular vesicle (fig. 16), it may be inferred that they are developed there, and that the subsequent bursting of the vesicle thus allows them to become free and scattered in such abundance as they are observed to be throughout the mucus-layer. Another remarkable character of this delicate vesicle is, that it is endowed with the power of motion, inasmuch as many may be seen on their first issuing to rotate upon their axes, and to undulate or prolong their cell-wall in different directions, while the granules of the mucus internally are in constant vibratory or molecular movement, like those of *Spirogyra* (produced perhaps by the irritability of the mucus); while the mucus itself *en masse* is continually moving to this side or that, and drawing all the granules which are imbedded in the moving portion in the same direction. Hence, with the exception of the contracting vesicle and a far more delicate texture, we have a cell corresponding in every respect to that of *Amœba* and *Spongilla*.

It will be remembered also, that in my description of *Spongilla* * it is stated, that the intercellular mucus which binds the cells together has a polymorphic power, like that of the cells themselves; and this appears to be the case, but in a much more limited degree, with the granuliferous mucus of *Nitella*, which, at the time of its issuing from the internode, in masses, undergoes a slow but appreciable change of form; and either throws out threads which adhere to the glass, or exhibits in these threads a distinct retractile movement when the latter separate

* Ann. and Mag. Nat. Hist. vol. iv. p. 36, 1849.

from their points of attachment. It is perhaps more to the breaking of these than to the "bursting of the vesicles" mentioned (p. 19), that the "jerking" movements seen every now and then in this mucus are to be attributed; at the same time, the severation of these threads thus uniting the masses of mucus may still be a vital act.

The "irregularly shaped bodies" (fig. 11), which are agariciform in the mucus of the large *Nitella* and *Chara verticillata* (figs. 12, 13), next claim our attention. They are of an opaque, yellowish colour, and bear a strong resemblance to starch as well as to fixed oil. It is stated (p. 4) that iodine only turns them of a "deep brown amber colour;" but since that, I have frequently found it produce in some a deep claret, almost amounting to purple tint, with portions here and there which were quite blue. When pressed however, under these circumstances, between two pieces of glass, part of their substance has, in addition, assumed a fatty consistence, of a brown amber colour. What are these bodies then; and whether do they belong to the globular vesicles or to the mucus of *Nitella*, or are they developed in both; and what is their origin? These are questions for our consideration which we shall now pursue. From the apparently promiscuous formation of starch and fixed oil in the nucle of *Nitella*, and from the formation of starch-grains, and, probably as often, fixed oil-globules in the protoplasm of the "green disk," it does not appear unreasonable to conceive that similar formations may take place in the mucus-layer (which is also the protoplasm) of the internode. But I have lately found that starch is plentifully developed in *Spongilla* towards the end of the season, when it is about to be left uncovered by the water, and that not only are large starch-grains to be observed, apparently in nothing but the intercellular substance, but that many of the cells also exhibit traces of starch among their greenish granular contents; and some spherical cells appear to contain nothing else but a translucent amyloiferous fluid; while there is no trace of starch to be found in any part of the capsule or its contents, nor in the newly developed *Spongilla*. With organisms then thus far alike in their products as *Nitella* and *Spongilla*, and the presence of an organism so much like *Spongilla* in the internode of the former, how to decide which produces these partly amyloid, partly fatty, agariciform bodies that abound in the mucus of *Nitella*, is a question which had better be postponed until we come to the development of the latter. In the meanwhile, with reference to their origination, I can state no more than I have done with respect to the origin of the starch-grains in the green disks, and the starch-grains and oil-globules which occur together promiscuously in the Diatomaceæ

and in other vegetable cells, viz. that they first make their appearance in the cavity and substance of the protoplasm; which latter is Cruger's view*.

In the small species of *Nitella*, these irregular bodies were almost as frequently found appended to, or in the walls of, a globular vesicle, in the manner of the circular disk or nucleus itself (fig. 15); frequently seen in plurality as well as singly within large globular vesicles in both species of *Nitella*, imbedded in their internal mucus; and it often, though by no means always, appeared to me, that the circular disk or nucleus passed into the irregular body. This seems a not unlikely origin for them, and would explain their situation when appended to a vesicle, loose in the granular mucus, or in plurality in the large vesicles; more particularly, as has before been stated, from these being the only positions in which the circular or elliptical disks (nuclei) do appear. At the same time, many may have had their origin in the mucus itself, just as the starch-grains of the green disk, perhaps in germs, and this would account for the minute ones; but whatever may be their origin, or whether they be a development of *Nitella* on the globular vesicles, they form part of the contents of the internode, and disappear in the course of the passage of the cell-contents into the so-called "gonidial cells," and the subsequent development of the monads.

With vesicles so nearly allied to *Amœba* and *Spongilla*, it also seems not improbable that they should take in substances of nutrition after a similar manner; that is, apparently through their cell-wall; and although in some cases the irregular bodies may be developed in the nuclei of daughter-vesicles which have not left the parent, yet in others they may have been taken in by vesicles in the way to which I have alluded, viz. for the sake of food. Hence we frequently see one imbedded in the internal graniferous mucus of a vesicle, and not unfrequently undergoing, to a certain extent, that rotatory motion which is presented by portions of food just introduced into the abdominal mucus of *Vorticella*, *Paramecium aurelia*, &c. But perhaps the most remarkable instance of this occurs with the green disks, more or less of which become displaced and insulated when the end of the internode is truncated, and thus appear to be caught up by the globular vesicles immediately the two come into contact (fig. 17). Donnè first called attention to this, terming the globular vesicles "grosses gouttes huileuses ou albumineuses," and his observation was confirmed by Dutrochet†. The

* Ann. and Mag. Nat. Hist. vol. xv. p. 317. See also Mohl's papers translated by Henfrey, with observations by the latter, *idem*, pp. 321-416.

† Ann. des Sc. Nat. Bot. vol. x. p. 348, 1838.

circulation of the mucus-layer itself is hardly more remarkable than the rapidity with which the green disks are whirled round upon their short axis horizontally or vertically, when they get into the abdominal mucus of one of these vesicles. If this explanation of it meet with disbelief, I can only repeat in its support, that the irregular bodies are similarly affected when they get into this position, though not to such a degree of rapidity, probably from their greater weight and ragged form (fig. 18), and that neither these nor the green disks exhibit this phenomenon when lying outside the vesicles; while the rotation of food, when it gets into the abdominal mucus, is a common occurrence in many of the Infusoria, especially in *Vorticella*, *Paramecium*, &c.

We now come to an important point of elucidation; viz. if the globular vesicle can enclose the green disks so rapidly when a few only of the latter are displaced, they should be able to enclose a far greater number when the whole of the *green layer* is broken up (figs. 19, 20). Hence it becomes much more likely that this should take place when the so-called "gonidial cells" are formed in the internode (fig. 21), than that portions of the loose mucus, as I had before supposed (p. 7), should wrap up certain numbers of the green disks respectively in their substance, and then pass into closed, transparent sacs or cell-walls. Led on from fact to fact, then, to this conclusion, we now see that the so-called "gonidial sac" is not a new formation, but a pre-existing "globular vesicle," which, when filled with green disks, is in an efficient state, as regards nourishment, to multiply itself by segmentation (fig. 22). That segmentation is the way in which the litter of monads is produced, would appear, first, from the cell-wall losing all power of motion, and apparently life (fig. 20); then the formation sometimes (probably always) of a secondary more delicate cell or coat within (fig. 21); afterwards a separation *en masse* of the granules and mucus from the brown or nutritive matter, now become effete (fig. 23); and, lastly, by the division of this into the litter of monads (figs. 24, 25). Whereas, in the propagation by ovules in the Amœbous cells, all foreign matter appears to be thrown off, and the ovules fully formed and separate previous to encystment and incubation. After the monads, formerly called "gonidia," have been developed, the inner cell disappears, and the outer one giving way from decay (?), they escape into the water (figs. 26, 27).

It is not always that this process can be so distinctly seen, because the brown matter seems sometimes to be so mixed up with the granules and mucus, that the monads appear to come directly out of the former, without a previous separation of the latter.

The production of the young Water-net, or *Hydrodictyon*, is not unlike this. Here a single gonidium grows into a long tubular cell, during which its internal surface becomes lined with a mucus-layer charged with chlorophyll-granules and starch-grains; this layer, when fully developed, divides up into gonidia, which, by mere change of position (Braun), force themselves into a new Water-net, or separate altogether, and pass out through a rent in the parent gonidium, now become a long cylindrical cell; at this moment also the existence of another more delicate cell, between the outer one and the mucus-layer, is demonstrated, in which the passage of the gonidia is momentarily arrested. Here, then, the chief apparent difference between this process of development or multiplication and that of the globular cell of the mucus-layer of *Nitella* is the introduction of foreign material for the support of the mass during the time it is undergoing division in the latter, and the preparation of it in the cell itself for this process in the former. Here also the cell-wall of the gonidium passes into the cell-wall of the mother-cell in *Hydrodictyon*, which corresponds to the so-called "gonidial cell" of *Nitella*, and is not a new secretion; while the internal delicate membrane which holds the gonidia in *Hydrodictyon* corresponds to the delicate cell-membrane which immediately surrounds the monads in *Nitella*; and the monads, as well as the gonidia of *Hydrodictyon*, appear to gain their proper covering from the contents of the secondary cysts, which coverings in time become respectively the mother-sacs of future litters. We shall also see by and by, that the same thing takes place in the segmentation of *Paramecia*.

The passage of the green disks *in situ* into monads or polymorphic cells, mentioned p. 8, is now easily understood; since, if the germ producing the first globular vesicle can get through the cell-wall of the internode without causing a suspension of its functions, a germ from it might easily get from the *mucus-layer* into the green disk of the *green layer*; and there, living upon the protein nucleus and green chlorophyll, take the place of the latter in the transparent cell, which, finally decaying, would allow the monad or monads thus produced to get into the cavity of the internode.

Viewing, then, the globular vesicles as an infusorial development, all difficulty in accounting for the changes which they occasion in the cells of the *Characeæ* disappears, and all changes which take place in these vesicles themselves become easily understood.

But we have yet to discover whether these vesicles existed *ab origine* in the mucus of the internode, and, if not, how and under what form they were introduced.

Probably the best way of pursuing this part of the subject is to commence with the development of the new plant from the nucule, by which we shall see under what form the mucus first appears.

The nucule of *Chara verticillata* (fig. 35 a), which is more or less ovate, consists of three coats, viz. an external or cellular, a middle or laminar, and an internal or delicate one, within which is enclosed a quantity of starch and oil, together with a little mucus.

The external coat (*b, b*) is composed of five long cells, twisted twice round the middle coat, side by side, so as to form a spiral plane, ending at the apex in a group of ten cells, the last of which are pointed; this group has been called the coronet. They all, and in every respect, answer in structure, &c. to the description given of the internode of *Nitella* in my first paper.

The middle coat (*e, e*), which represents in relief and depression the spiral lines impressed upon it by the cellular one, consists of several very thin laminæ, structureless, homogeneous in composition, and of a dark brown colour by transmitted, but black by reflected light.

The internal coat (*d, d*) is a fine delicate colourless membrane, which frequently adheres very strongly to the middle coat, and so much resembles the laminæ in the latter, that the whole together present a structure similar to that of the thickened cells in old filaments of *Conferva glomerata*. When treated with iodine alone, this, as well as the middle coat, assumes a reddish-brown colour; but when sulphuric acid is added, the internal coat (as well as the next layer to it, which ought perhaps to be considered a part of it) turns blue, while the middle coat remains unaltered.

The starch and oil are in pellicled smooth grains, of a sub-round, subangular, elliptical or compressed form. These grains are larger in the centre than at the circumference, where they become almost molecular, and are mixed up with a layer of mucus, which supports the whole in an ovoid form.

This external mucus may be the preserved protoplasm, and there may be a cytoblast also ready to assist in the formation of the first cell; as in *Spirogyra*, where both protoplasm and cytoblast appear immediately the contents of the resting-spore burst forth to form the new cell.

Such is the composition of the nucule, in the contents of which I have never seen anything like the "globular vesicles" of the mucus-layer; not even where the germinating matter has perished, and the nucule has remained for several weeks afterwards exposed to the decomposing action of the water. Neither have I even seen anything like the globular vesicle, or

monad developed from it, in the cells of the filaments producing the antherozoids of the *globule*.

We have now to examine the development of the first few cells of the new plant successively, in order that we may trace the development of the mucus-layer.

In the Characeæ, as in *Cladophora*, but not as in *Spirogyra*, the coat immediately covering the grumous contents of the spore in one case and the nucule in the other, appear to be prolonged into the cell-wall of the new plant. I infer this from the cell-wall of the first internode being so firmly attached to the inner coat of the nucule that it cannot be separated from it without rupture, since the black colour of the middle coat prevents our seeing how the continuation is effected after the manner of *Cladophora*, where the old cell and the spore-capsule are equally transparent. By a prolongation of the internal coat into the new cell-wall, I mean that the former becomes soldered to the latter, as the latter is secreted or formed by the protoplasm of the nucule.

Having come to this conclusion, we will now follow the extension of the new plant to the sixth cell, exclusive of the cavity of the nucule. At this period we shall find it about one-fiftieth of an inch in length, and the circulation or full development of the mucus-layer only established in the cell next the nucule, which we shall designate the first, and so on to the terminal one, which will be the sixth.

Beginning then from the sixth, or youngest cell, and tracing the development backwards, or towards the nucule, we shall find the following appearances:—

In the terminal or sixth cell, which is not fully formed, nothing is seen within the cell-wall but a mass of small spherical hyaline vesicles of different sizes, and the barely perceptible rudiments of the green disks (fig. 36). In the fifth the number of vesicles are diminished, by some being larger than the rest, especially two in the centre, and the rudiments of the green disks more distinct. In the fourth the two large vesicles (spaces?) have united into one, and many of the smaller ones have broken down into, or have been replaced by mucus; the rudiments of the green disks are more evident. In the third the same changes are seen, but still more advanced; while in the second the central space is much larger, though irregular in form; the mucus increased in quantity, apparently at the expense of the hyaline vesicles, which are now very few; and the whole beginning to move gradually round the cell. In the first the circulation is established; no hyaline vesicles are seen in the mucus, though already it presents some of the “irregularly shaped bodies,” and the green disks are found.

Thus we see that the mucus-layer appears originally to be formed by cells of extreme tenuity, and that even the first cell which presents a circulation may have the irregular, agariciform bodies in it.

Now the same thing takes place in the roots (fig. 37), which are given off in a circlet from the first internode or junction of the first cell with the cavity of the nucule (fig. 35 *e*), and at this period far exceed the plant in length and amount of development. They however present these exceptions, viz. that they are as transparent as glass, from having no green disks, and for some time bear a large cytoblast in their extremity (*f*), which however, as the root elongates, adheres to one side (*g*), and there appears to undergo fissiparation and throw out a new circlet of roots (*h*), while the old root ends some distance beyond this in a *cul de sac* without further development.

Thus we have the green cells of the plant at first, as well as the roots, so transparent, that the delicate hyaline vesicles which precede the formation of the mucus-layer can be distinctly seen through them; while afterwards, when the mucus is fully formed and in circulation in both, and an equal degree of transparency still remains in either, no vesicles whatever can be seen, nor anything like the nuclei belonging to the "globular vesicles;" though, as before stated, a variable number of the irregular bodies may already be present.

Hence we may fairly infer two things, viz. first, that the globular vesicles at least do not exist *ab origine* in the mucus-layer; and, secondly, that the irregular-shaped or agariciform bodies may be formed in it independently of the presence of the globular vesicles.

As to the external source of the globular vesicles, it does not seem improbable, now that we know them to be so like Rhizopoda in almost every respect, and to produce monads which pass into small amœbous cells, that they should originally come from germs of their family; particularly as all the freshwater species dwell upon the freshwater Algæ, are chiefly dependent on the mucus of their cells for food, and are always found in greater or lesser numbers creeping over their tender shoots, or present at the formation of the resting-spores, when the cell-membrane is so soft that it can be most easily penetrated.

If we saw an *Arcella* or *Diffugia* developed from one of these monads which pass into an amœbous form, we should have no doubt about the matter; nor ought we to have much, I think, if we can find one Alga developing itself in another under similar circumstances.

For instance, we will take *Edogonium* germinating in the midst of the living cells of a filament of *Oscillatoria* (*princeps*, Kg.).

Happening one day to be examining the spores of *Cladophora*, with which *Conferva*, *Ædogonium*, and this *Oscillatoria* had been mixed and kept in a glass for eight or ten months, for the sake of observing the development of the former, I noticed that in several of the filaments of the *Oscillatoria* there were green cells developing themselves, so much so as to thrust aside the cells of the *Oscillatoria*, and break through the thickened sheath of the old filament, after which they passed into a filament like that of *Ædogonium*; but not being sure of the family of the Alga, I waited for the determination of this, until chance favoured me with the view of a filament not only extending along the sheath of one of the *Oscillatoria* mentioned, but also bearing in addition the peculiar spore of *Ædogonium*. Although in many of these instances the cells of the *Oscillatoria* were dead, yet in several the cells of *Ædogonium* were growing in the midst of the living cells, and bursting through the sheath where the latter, from its transparency and general appearance, bore no signs of previous injury (Pl. IX. fig. 15).

Now here, neither the spore of *Ædogonium* nor its sporule or gonidium can be supposed to have entered the sheath of the *Oscillatoria*, as they, from their size, would probably have caused such an injury of the sheath as would have led to the death or rupture of the filament at this part. Hence we may infer, that these cells arose from germs of extreme minuteness, which nevertheless had the power of penetrating the Oscillarian sheath. May not the "globular vesicles" of the mucus-layer of *Nitella* have been derived from germs of Rhizopoda equally small, but endowed with a similar power? Many small species of *Ædogonia*, like Rhizopoda, have a great tendency to dwell on the outside of the filamentous Algæ; old filaments of *Cladophora* are frequently covered with *Ædogonium*, and it seems not improbable that the minute germs of both Rhizopoda and *Ædogonium* may have a like parasitic tendency, as well as power to penetrate into their interior.

Lastly, we have to consider how the germ, when so small, can possess such power of penetration; a proposition which is easily solved when we remember that almost every observation we make on structural alteration in vitalized parts presents us with an instance of bodies travelling from one part to another, or, in other words, effecting change of position by a solution of the material which obstructs their progress.

As, however, it is desirable to support this by a case in point, or one as nearly allied as possible, I will cite a development belonging to the class under consideration, which takes place in the cells and resting-spores of *Spirogyra*.

Just after the conjugation of *Spirogyra*, a number of spherical

cells filled with minute refractive granules frequently make their appearance within the mucus-layer of the cell, and when the former shrinks from the sides of the latter, these spherical cells become wrapped up in it (fig. 9 a). In this position, if their granular contents, which the sequel will show to be germs, were to be liberated into the cell of *Spirogyra* through the bursting of their parent-cells, they would in all probability perish, for the parent-cells have apparently already subsisted, and brought their progeny to the state of germs, on the nutrient contents of the cell of *Spirogyra* in which they have become developed. But to provide for this, these spherical cells have each the power, not only of developing a blind tube, which by the process of solution to which I have adverted can pass through the cell-wall of the *Spirogyra* for the exterior liberation of their germs, but also to tubulate with each other if necessary, when the contents of all the cells together may be thus liberated by one or more tubes only, as the case may require (fig. 9 b); and often they will send one through the septum of the cell into the resting-spore of the next cell, which being full of nutritious matter, immediately furnishes food for the whole brood (fig. 10 e). Hence if a blind tube of a small cell of this kind can make its way through these comparatively hard membranes by simple solution, for it can hardly be supposed that it does so by any mechanical power, the smallest germ may be able to enter the cell or sheath of a filamentous Alga after the same manner. That the granules of these spherical cells, which are of different sizes, and, motionless at first, become locomotive, swarm about the cell, and then pass out of the tubular prolongations, has been proved to me by ocular demonstration (fig. 9 b').

Thus I think sufficient evidence has been brought forward to show, that the globular vesicle of the mucus-layer or protoplasm in the cells of the Characeæ is a parasite, probably of a rhizopodous nature, apparently introduced after the development of the young plant, and not impossibly under the form of a germ, and after the manner of the instances last mentioned.

I have yet however to add a few observations on developments of a similar kind in the cells, not only of *Spirogyra*, but in the body of an infusorium, viz. in *Euglena*.

During conjugation, the *Spirogyræ* are particularly infested with these parasites, if such they may be termed, and the rapidity with which they make their appearance at this period would lead to the conclusion that the germs from which they originate must have pre-existed in the cells in which they appear, as in the Characeæ; that is to say, without interfering with their functions. Be this as it may, the peculiar tubulating cell just mentioned is very commonly seen in *Spirogyra* at this time (figs.

9, 10); and not only in *Spirogyra*, but also in the dead bodies of some of the Furcularian Rotifera (fig. 16). To what infusorium this cell belongs I am ignorant; but from having seen it associated with *Astasia* under circumstances indicative of one being the product of the other, and more particularly from finding young *Astasia* developed in the cells of *Spirogyra* to a great extent where the tubulating cell-development was equally prevalent (fig. 9), with no mother-cells present in the cell of *Spirogyra* containing the young *Astasia* to thus account for their origin (fig. 9 d), I have supposed that they might have come from the germs contained in the tubulating cells, which germs have been conveyed into the cells of *Spirogyra* in the way above described (fig. 10). However, whether the tubulating cells are connected with *Astasia* or not, young *Astasia* are also developed within the cells of *Spirogyra* to a great extent (fig. 9 d); and although they at first have almost as much polymorphism as an *Amæba*, still they retain their cilium, and after a while assume the form and movements peculiar to *Astasia* (fig. 9 d'). I might here mention, that on one occasion I saw a large *Amæba* with a long cilium, at one time assuming the form of *Astasia*, and at another that of *Amæba*, which thus gives us the link between these two infusoria. The cilium however had not the power of the filament of *Astasia*, though it occasionally became terminal.

Besides these developments in the cells of *Spirogyra*, there is the one described by Professor Pringsheim*, and frequently a development of long, slender, colourless filaments, which have a writhing movement like that of an injured earth-worm. Some of these filaments present numerous granules in their sheath, and a faint appearance of cell-division; and I think that I have seen such filaments coiled up in mother-cells within the *Spirogyra*-cell. The same kind of filaments occasionally appear in *Closterium acerosum*, when its contents are passing into dissolution; but long before the chlorophyll has changed colour, or putrefaction has commenced. To enumerate all the developments of this kind, however, which take place in the filamentous Algæ is not my present object, and the only other development of the kind that I need allude to here is that which frequently occurs in *Euglena*.

This is also of a Rhizopodous character, and at first I thought it might be merely another form of *Euglena*, as *Acineta* is but another form of *Vorticella*; but subsequent observations convinced me that this was not the case. I was led to notice this development by an apparent metamorphosis of the cell-contents of

* Ann. & Mag. of Nat. Hist. vol. xi. p. 210, 1853.

some fixed and capsuled *Euglenæ* (which I had had under observation) into granulariferous *Amæbæ* of a pinkish colour within the old cell of *Euglena* itself (fig. 14); and the presence of several such *Amæbæ* creeping about the watch-glass, while many of the cells of the *Euglenæ* (*viridis*?) were empty, or only contained a little red effete matter, left no doubt in my mind as to the origin of both colour and infusorium.

It was also observed in some instances, where the contents of the *Euglena* had passed into an Amœbous mass, that the latter underwent a kind of segmentation, so that several (perhaps eight) small *Amæbæ* were developed instead of one large one. All this became confirmed on another occasion, when watching some large *Euglenæ* of a purse-like or ovate form (*Crumenula*, Dujar.?), wherein the peculiar embryonic cells of the species (fig. 11 *a, b*) (for each species has its peculiar-shaped cell of this kind, and they are all composed like those of *Spongilla*, viz. of a transparent compressed capsule, and a faint yellowish translucent nucleus of nearly equal size) had been developed. Expecting daily while under observation to see the embryonic cells liberated by the rupture of the parent-cell, I noticed on one occasion that several of the latter had become surrounded respectively by a delicate granulariferous *Amæba*, and from that moment I knew that all further progress of the embryonic cells must cease, for the *Amæbæ* appear to destroy every living organism which they enclose. However, in a few days the *Amæbæ* had left the *Euglenæ*, but the rich green colour of the latter had faded; indeed there was hardly any colour at all left, and the embryonic cells, with which they were originally filled, began to diminish in number, and give place, at the same time, to a uniform granular matter, which soon segmented itself into another development of six or eight globular masses, much larger than the embryonic cells (fig. 12). Such a process at first seemed to be proper to the *Euglenæ*, as the contents of one and all successively became thus affected; but presently the spiral coats of the *Euglenæ* respectively gave way, and the globular masses being liberated, began to creep about under the form of *Actinophrys* (fig. 13 *a, b*). It then seemed evident that the germs of an *Amæba* had been introduced, and that they had become developed in the cell of the *Euglena* at the expense of its embryonic cells; but whether or not they had been introduced while enveloped in the *Amæbæ* mentioned, there are no facts to decide.

This apparent metamorphosis of the cell-contents of *Euglena* into Rhizopoda is not only mentioned for the purpose of instancing another of the developments under consideration, but also for preventing others from being misled, as I was myself at

first, into considering this as an *alternating* form of *Euglena*. I have since almost satisfied myself that *Euglena* conjugates, and that the cells which I have termed embryonic pass into *Euglenæ*. But had these cells not been present, there would still have been room for doubt, inasmuch as a development of the same kind takes place in some *Amæbæ*, apparently in connexion with the nucleus alone, with which *Euglena* also is provided (fig. 11); at the same time that we know the *Amæbæ* to produce embryonic cells like *Spongilla*, which cells again are like those of *Euglena*. Some *Amæbæ* at least then, propagating by germs or gemmæ, according as the granules are set free singly or in masses, as well as by embryonic cells, it might be questioned whether *Euglena* does not also possess these two processes. Again, when we know from Stein, as before mentioned, that *Vorticellæ* pass into *Acinetæ*, and *Acinetæ* produce full-formed *Vorticellæ*—and I have seen some *Amæbæ* also produce full-formed *Vorticellæ*—it becomes necessary to ascertain among these changes, what are parasitic or foreign developments, and what are merely *alternating* forms of the same species,—inquiries which are extremely intricate and perplexing, but which must be prosecuted thoroughly before we shall be able to adjust these matters, or arrive at a true history of the vital œconomy of both Infusoria and Algæ.

With reference to the development of the “ciliated sacs” mentioned at p. 14, I have since ascertained, that the variety of forms which they assumed depended upon their having been forced from their cysts before they were fully developed; for I have since not only had an opportunity of examining them when just liberated from the latter in the natural way, but of watching for a long time two individuals of large size and full development, which I found free among some filaments of *Cladophora*. Having thus called attention to this development, I will describe the infusorium which appears to be the source of it. It is a *Paramecium* closely allied to *Nassula*, and, from the likeness of the oral orifice to the human ear, I propose for it the name of “*Otostoma*.”

OTOSTOMA, H. J. C. (new species) (Pl. IX. figs. 6, 7, 8).

Body ovoid, of a light brown colour, covered with longitudinal lines of cilia (figs. 7, 8). Mouth ear-shaped, in a depression situated about the junction of the anterior with the middle third of the infusorium (fig. 7 *a*); buccal cavity broad, short, curved downwards, and a little upon itself outwards, plicated longitudinally in parallel lines (fig. 6 *a*). Anus terminal; gland or nucleus long, fusiform (fig. 7 *c*), situated between the buccal cavity and the contracting vesicles (fig. 7 *d, d*), which are double, and

connected with a set of vessels something like those of *Paramecium aurelia**.

The individuals which become encysted in the internode of *Nitella* I have never been able to see clearly, on account of their rapid movements and gorged state with the green disks (fig. 1); but the depression indicating the position of the mouth can be seen, and two contracting vesicles. After the segmentation, which stops at 2, 4, or 8, and full development of the new brood has taken place, the green matter, now become brown, is thrown off as effete (figs. 3, 5), like that of the "globular vesicles" after the monads appear, and the cysts giving way, the new infusoria come forth, presenting the arrangement of cilia, form of nucleus, and colour of *Otostoma* (fig. 5); but there is only one contracting vesicle at this time, and the mouth is not so rigidly fixed or defined as in *Otostoma*, probably from the tender age of the new animalcule.

During the process of segmentation, the external and internal cysts at first appear to be newly secreted, and the old ciliated integument to be divided up into coats for the new litter; but this does not correspond with what has been before stated, where the old coat seems to be metamorphosed into a cyst-covering for the new litter, and another delicate cyst secreted within this (figs. 2, 3); while the internal substance then divides itself up into 2, 4, or 8 sacs, as the case may be, and each division develops a new ciliated coat for itself (figs. 3, 4).

The presence of a few monads, which probably formed part of the contents of the internode before they were gorged by the infusorium, and retained their life by getting between the cysts (fig. 3 *b, b*), favours the view that the external cyst was the originally ciliated coat of the parent infusorium.

Lastly, I have to give an explanation of the locomotive power afforded to the fragments of the spiral bands of "*Zygnema*" mentioned at p. 16, which I now feel convinced did not derive this power from their own mucus, but from having been enclosed within the bodies of delicate *Amœbæ*, which afterwards crept about under the radiated form of *Actinophrys*.

Circulation.

It has been shown above, that rhizopodous cells abound in the mucus-layer of the old internode of *Nitella*, but at a very early period do not appear in the internodes or roots of the young plant. Hence it becomes necessary to adduce further

* In a future communication, I propose describing this "system of vessels," which are excretory at the contracting vesicle; when I shall also recur to the description of *Otostoma* more particularly.

proofs of the mucus-layer, minus the rhizopodous cells, possessing the "inherent power of mobility" mentioned at p. 18, which was then assigned to it, chiefly upon the inference that the mucus of the mucus-layer furnished the cell-wall of the so-called "gonidial cells," and that the polymorphic and locomotive power of the latter at the commencement was indicative of the same power existing in the mucus in its amorphous, plasmic state. That such a deduction would be inadmissible if the development was to be considered infusorial, I stated in my "Postscript" (p. 22); and now that the so-called "gonidial cells" have been shown to be the globular vesicles of the mucus-layer, and of a rhizopodous nature, the fallacy of such an inference is much more evident. But I also observed, that there were still "sufficient reasons left" for my considering the rotatory motion of the mucus-layer due to an independent contractility.

I have now to give further proof of this; but, unfortunately, in doing so I must confine myself to what the mucus-layer exhibits while within the internodes and roots of the young plant, supported by what it may be inferred to possess from analogous motions exhibited by the mucus-layer of other allied organisms; for the cells and the roots of the young plant, at that time when alone we have the power of determining that there are no rhizopodous cells in them, furnish too small a quantity of mucus for our watching it in the manner so easily effected when issuing from the large internode.

To pursue this inquiry, then, we have first to satisfy ourselves that the motions in *Nitella* and its allied organisms are in homologous structures, and then to see how many kinds of motion this structure presents.

Of their being in homologous structures there can be no doubt, because the mucus-layer in all is the protoplasm of the cell; and they are of two kinds, viz. one of general irritability, and the other of polymorphic and locomotive power.

The first kind, or that of general irritability, is manifested by the trembling movement of the granules which are imbedded in the mucus-layer itself, more than by that of the moving agent or mucus, which can hardly be seen, from its transparency. This motion of the granules, which is similar to that termed "molecular," is observed in the mucus-layer of the spine-cells of *Nitella* in which no circulation has ever existed, and in that of the internodes when the circulation is temporarily arrested. It is also seen in *Cladophora*, and particularly in *Spirogyra*; in the Desmidiæ (*Closterium*, &c.); in the Diatomaceæ (*Navicula*, &c.), and in the mucus of the cell of *Spongilla*, &c.

The second kind, or that of polymorphism and locomotion,

includes the rotatory movement seen in the cells of many aquatic plants besides the Characeæ, in which the whole of the mucus-layer changes place. In *Serpicula verticillata* (Roxb.), the green disks are imbedded in the mucus-layer promiscuously, and are carried round the cell with it; and in *Tradescantia* the cytoblast also goes round with the mucus-layer. To this perhaps might be added the polymorphism of the granular mucus occasionally witnessed on the septa between the cells of *Spirogyra* (p. 19), unless this also be owing to the presence of a rhizopodous organism.

There is yet however another kind of motion, which has been observed in *Closterium Lunula*, and some other Desmidiæ; and this, according to the Rev. S. G. Osborne's observations, confirmed by Mr. Jabez Hogg*, is owing to cilia situated on the surface of the mucus-layer. By their action, which appears to be very irregular, and is certainly very perplexing, the brown corpuscles are urged backwards and forwards, or circulated more or less round the frond. The same kind of motion is witnessed in similar corpuscles in *Spirogyra*, which, coming next to *Closterium* in point of organization, may be found to be provided with similar organs. There is no analogy, however, between the circulation of these corpuscles and the rotatory movement of the mucus-layer of *Nitella*, nor between it and the circulation of the axial fluid of the latter and its particles. To assume that the mucus-layer of the internode of *Nitella* is urged on by cilia, would be to assume that the cilia are not on the surface of the mucus-layer, as in *Closterium*, but on the inner surface of the green layer; and then, in the roots, that they are on the inner surface of the cell-wall, for there is no green layer there,—which would be absurd. Again, we can see that the particles contained in the axial fluid are impelled by the irregular surface of the mucus-layer, and this seems quite enough to account for this circulation.

As regards the general irritability of the mucus-layer, this by itself is of course no proof of locomotive power, but occurring in homologous structures, it allies them in point of property as well as structure, and therefore affords additional reason for admitting the phænomena observed in one as confirmative or explanatory of those which are observed in another organism of the same or similar nature. Hence, if we have evidence of a locomotive power in the mucus-layer of the cells of *Spirogyra*, and the object to be gained by it, as well as evidence of the same power in the mucus-layer of the internode of *Nitella*, though the object be *not* manifest, our conclusion, that the latter is

* Quart. Journ. Microscop. Soc. vol. xi. p. 234, 1854.

owing to an innate contractility, and not to any foreign organism or any other moving power, is much more satisfactory than if it were unsupported by the movement of the mucus-layer in *Spirogyra*, where its nature is obvious from the object gained by it.

I allude to the movements which take place in *Spirogyra* during conjugation, when the mucus-layer, retracting from the cell-wall of one filament, carries its contents through the tube of intercommunication, across to the cell of the opposite filament.

To refresh the memory of the reader, I might here briefly sum up what takes place on this occasion. The first step on the part of the mucus or protoplasmic layer is to soften a small portion of the cell-wall; it then presses upon this so as to force it forwards into a tubular prolongation to meet a similar one from the opposite filament; the two mucus-layers dissolve the partition which interrupts their union; the mucus-layer of one cell then retracts from its cell-wall, gathers up the spiral bands and cytoblast, and mingling with its fellow at the junction of the tubular prolongations, passes over into the opposite cell with the return of the latter, and there amalgamating with it thoroughly, becomes capsuled and passes into a spherical or elliptical spore, as the case may be. Now here there is no addition of material to cause the mucus-layer to grow and protrude from its cell like a bud or young shoot,—it is an act performed by the mucus-layer alone, and that too almost faster than the hour-hand travels round the dial of a watch; indeed, it is performed so quickly in *Closterium Ehrenbergii*, where a similar process takes place, that according to the Rev. W. Smith, who has watched it, the discharge of the endochrome and formation of the sporangia are accomplished with such rapidity, that this may be seen to take place in the field of the microscope, “the whole operation not occupying more than a few minutes*.”

Again, in *Ædogonium flavescens* (Kg.), I was lately fortunate enough to see the contents of one of the cells wrapped up in their protoplasmic sac, actually leave the cell, form into a spore, and whirl off in the manner of zoospores generally. The cell-wall bore no appearance of spore-dilatation, though the density of the gonimic contents indicated that it would sooner or later have done so; it was a terminal one, and the septum of the free end had probably been broken when the other part of the filament had been torn from it in preparing the mass for microscopical examination. As the last part of the cell-contents left their old cavity distinct locomotion was seen in the mass, and when the whole had become extricated, several twitchings of the pro-

* Ann. and Mag. Nat. Hist. vol. v. p. 8, 1850.

toplasm, apparently of adjustment, took place. It then assumed a globular and afterwards an ovoid shape, when the small end becoming transparent and throwing out a wreath of active cilia, it bounded off and was soon undistinguishable from other spores of the same kind which were present in equally active motion. At the moment of its exit I observed a delicate membrane at some distance around it which disappeared (by bursting?) immediately the cilia began to play.

Having thus brought forward incontestable proof of locomotive power in structures homologous with the mucus-layer of the cell in the Characeæ, I shall now only add another instance of the kind mentioned (p. 19), where a *partial* movement of the mucus-layer, again in *Chara verticillata*, afforded direct evidence of its possessing the independent power of contractility in question. This occurred in a very young plant where the roots were nearly an inch long, though not more than the 500th of an inch broad, and, as before stated, as transparent as glass. While tracing one of these, in which the circulation appeared to have ceased, I came to a part where there was a slight movement of the mucus-layer, which increased up to a certain point, and then as gradually subsided again. It was a thickened portion, but apparently composed of nothing more than transparent mucus charged with a number of granules. It was moving towards the extremity of the root, and was seen to pass through that part of the latter which was kept in the field of the microscope for the purpose, leaving all the mucus as still behind it as that which was beyond the moving portion. To conceive after this that the mucus-layer of the Characeæ is endowed with a locomotive power, seems not difficult, if we cannot conclude that by this power also it moves round the internode.

Since the above was written, I have read the following passages in Cohn's 'Natural History of *Protococcus pluvialis*' (1850), translated by Busk for the Ray Society (*loc. cit.* p. 532, 1853), and they so accord with my own conclusions on the subject, that I cannot do better than insert them here, as a termination to an argument in favour of the moving power of the mucus-layer or protoplasmic cell of the Characeæ, instituted for the purpose of conveying a similar impression:—

“From these considerations it would therefore appear, as certain as it can be made by an empirical deduction from the premises in such a subject, that the protoplasm of botanists and the contractile substance and sarcode of zoologists, if not identical, are at all events in the highest degree analogous formations.

“Whence, the distinctions between animals and plants viewed in the above light must be thus understood: that in the latter the contractile substance, as the primordial utricle, is enclosed

within a rigid ligneous membrane, which permits only an internal motion, evidenced in the phænomena of circulation and rotation ; while in the former it is not thus enclosed. The protoplasm in the form of the primordial sac is, as it were, the animal element in the plant in which it is *confined*, being *free* only in the animal kingdom."

Casual Notes on the Characeæ.

Circulation.—I have repeated the experiments of Amici, Dutrochet and others by ligaturing the internode of the large *Nitella* at several places with similar results. The circulation has hardly been arrested ; but to succeed well in this, an old internode must be taken. On one occasion an inch of one of these long internodes was cut out of the centre with a blunt pair of scissors and placed on a glass slide in a little water, and under a piece of glass about the same width ; the water therefore but just covered its extremities ; in this portion the circulation continued in opposite directions (for fortunately one of the white lines or "lines of repose" was uppermost) for ten minutes by the watch ; the larger bodies ceasing to circulate first, and lastly the molecules.

Tenacity of life.—The internodes which I ligatured perished after a few days ; indeed this is the common fate of the Characeæ ; but the nodes retain their vitality, and the small internodes also. Single, isolated cells and small internodes, which can hardly be seen with the naked eye, frequently retain their green colour, and keep up a continued rotation of their mucus-layer for eight and ten months after they have been separated from every part, dead and living, belonging to the parent plant ; but they do not appear to increase in size in the least. Those little shoots which spring from the cells of the nodes (the bulbels probably of Montagne*) would probably grow into new plants if favourably situated for nourishment, as the nodes commonly throw out roots as well as shoots, when the other parts of the plant are threatened with destruction.

Endosmosis.—The rapidity with which water passes through the cell-wall of the internode, as shown by the experiment detailed at the commencement of this paper, indicates the amount of fluid that might pass from one internode to another through contact even of their extremities ; and hence how the nutritious fluid formed in the roots might also find its way from the roots to the extremities of the plant.

Germination.—The nucules of *Chara verticillata* which were placed in water on the 21st of March germinated at the end of

* Ann. des Sc. Nat. Bot. 3 sér. t. xviii. p. 65.

twenty-six days; those placed in water on the 2nd of May after sixteen days: of fifty nucules placed in water on the 1st of September none have germinated up to the present time (November 15th). At first the young plants appeared in the form of *Nitella*, but not having grown beyond three-quarters of an inch in length, they did not pass into that of *Chara*. Thus, *Chara* begins in the lower form of *Nitella*; and the oldest internodes of the large *Nitella*, where the endochrome has disappeared, are fluted like the stem of *Chara*, but not celled like it. Out of the first set of nucules (viz. thirteen) four only germinated, and one of these threw out two plants, but both did not grow with equal rapidity, one remaining abortive or stationary.

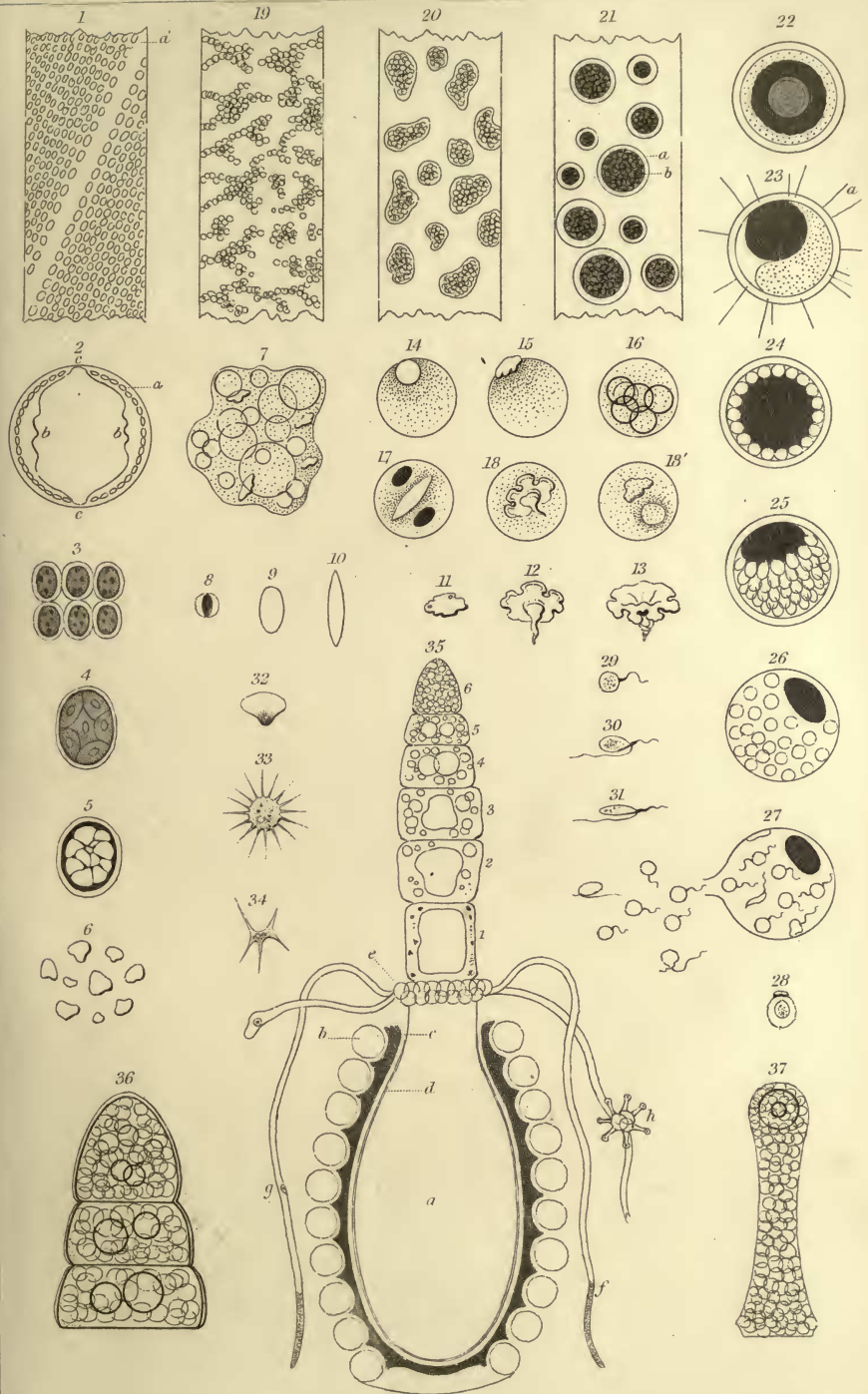
Bombay, 15th November 1855.

EXPLANATION OF PLATES VIII. AND IX.

PLATE VIII.

- Fig. 1.* Portion of an internode of *Nitella*, showing the arrangement of the "green disks" in the "green layer;" also (a) one of the white lines or "lines of repose"*.
Fig. 2. Transverse section of ditto, showing (a) the "green layer;" (b, b) internal border of "mucus-layer;" (c, c) "lines of repose."
Fig. 3. Portion of the green layer showing its structure; also the chlorophyll-mucus of the "green disk" and its transparent cell.
Fig. 4. Cavity of "green disk" divided into compartments with a granule in each.
Fig. 5. Ditto nearly filled with starch-grains, the chlorophyll having almost disappeared.
Fig. 6. Starch-grains of ditto, separate.
Fig. 7. Portion of the "mucus-layer" as it issues from the internode, containing the "globular vesicles," "circular disks," irregular bodies and granules.
Fig. 8. "Circular disk" of small *Nitella*, with molecular-formed nucleus contracted into an oval shape. 9. Ditto from mucus-layer of *Chara verticillata*. 10. Ditto from mucus-layer of large *Nitella*.
Fig. 11. Irregular body from mucus-layer of small *Nitella*. 12. Ditto agariciform, from *Chara verticillata* and large *Nitella*, inferior view. 13. Ditto ditto, superior view.
Fig. 14. "Globular vesicle" with circular disk or nucleus *in situ*, surrounded by granuliferous mucus.
Fig. 15. Ditto with an "irregular body" in the position of the circular disk or nucleus.
Fig. 16. Globular vesicle containing a plurality of circular disks.
Fig. 17. "Globular vesicle" of large *Nitella* with disk or nucleus *in situ*, surrounded by granuliferous mucus, in which are imbedded two

* All these figures should be viewed as diagrams delineated after nature as far as circumstances would permit; and should any discrepancy be found between them and the text, the reader is requested to be guided by the latter.





“green disks;” as they are situated when seen to undergo rotatory motion.

- Fig. 18. “Globular vesicle” of large *Nitella*, containing agariciform “irregular body.” 18'. Ditto of small *Nitella*, containing in addition to its nucleus an irregular body imbedded in its granuliferous mucus; as it is situated when seen to undergo partial rotatory motion.
- Fig. 19. Portion of internode of *Nitella*, showing the breaking up of the green layer preparatory to grouping of the green disks.
- Fig. 20. Ditto, with green disks grouped or enclosed in the “globular vesicles.”
- Fig. 21. Groups which have assumed a spherical form: (a) globular vesicle or so-called “gonidial cell” stiffened and clarified, yet capable of projecting ambulatory processes (see fig. 23 a); (b) secondary coat circumscribing granuliferous mucus, green disk, &c.
- Fig. 22. “Globular vesicle” showing internal granuliferous mucus circumscribed by secondary coat, mass of green disks, and “circular disk.”
- This form is often seen without the mucus in a perished, half-developed state, when the “circular disk” is always particularly evident; thus with the other elements of the cell at once indicating its identity with the “globular vesicle” and rhizopodous nature.
- Fig. 23. “Globular vesicle” showing secondary coat, granuliferous mucus, and mass of green disks all now separated; (a, a) stiffened ambulatory processes.
- Fig. 24. Ditto, with granuliferous mucus presenting a mulberry form of segmentation. Cell about 1-300th of an inch in diameter.
- Fig. 25. Ditto, lateral view.
- Fig. 26. Ditto, after separation of the segments into monads, and disappearance of the secondary coat.
- Fig. 27. Ditto, bursting and giving exit to the monads, green disks, &c., and other effete matter contracted into a small brown nucleus.
- Fig. 28. Small “globular vesicle” with “irregular body” in the position of the nucleus, developing one monad only. Cell or vesicle 1-2150th of an inch; monad 1-4300th of an inch in diameter.
- Figs. 29, 30, 31. Monads of the globular vesicles or cells assuming different forms. All about 1-4800th of an inch in diameter when globular.
- Figs. 32, 33, 34. The same after a few days' growth; now about 1-2150th of an inch in diameter, assuming the forms of *Amæba* and *Actinophrys*; with contracting vesicle.
- Fig. 35. Vertical section of a young plant of *Chara verticillata*, with nucule still attached. (a) nucule; (b) external cellular coat; (c) middle or laminated black coat; (d) internal delicate coat; (e) circlelet of roots springing from cells of first node; (f) second position of cytoblast, viz. at the termination of the granuliferous mucus which fills the extremity of the root; (g) third position of the cytoblast, viz. when attached to the side of the root at some distance from the granuliferous mucus of the extremity; (h) circlelet of roots arising from the cytoblast so situated. The small figures, 1 to 6, indicate cells of the stem in successive stages of development; showing that the formation of the “mucus-layer” is preceded by the presence of a mass of hyaline, spherical vesicles of different sizes, which at first fill the young cell.
- Fig. 36. Last three cells (viz. 4, 5, 6) of fig. 35, more magnified.
- Fig. 37. One of the new root-buds of (h), fig. 35, magnified, to show that